SAES-422 Multistate Research Activity Accomplishments Report – Year 2022

BASIC INFORMATION
Project No. and Title: NECC2001 : Sustainable Farm Energy Production and Use
Period Covered: 10/01/2021 to 09/30/2022
Date of Report: 01/27/2023
Annual Meeting Date: 12/01/2022

PARTICIPANTS
Dr. Wang (Illinois); David Specca (Rutgers); Dr. Ralph Hall (VT); Dr. Ron Meyers (VT); Dr. Fathel (PSU); Dr. Ciolkosz (PSU); Dr.Mehrizi-Sani (VT), Dr. Cundiff (VT); John Ignosh (VT)
Via ZOOM: Dr. Lansing & Dr. Schiavone (Maryland); Dr. Joshi & Charles Gould (MSU); Dr. Yang (Connecticut); Robert Coville (Cornell)

BRIEF SUMMARY OF MINUTES OF ANNUAL MEETING

THURSDAY, DECEMBER 1, 2022

AGENDA
NECC2001: Sustainable Farm Energy Production and Use
Annual Meeting 9:30AM-3:30PM December 1, 2022
Dept. Biological Systems Engineering
Human and Agricultural Biosciences Building
Virginia Tech
1230 Washington St SW
Blacksburg, VA 24061

IN-PERSON EDUCATIONAL TOUR & PRESENTATIONS 9:30 AM - 1:00 PM
Participants: Dr. Wang (Illinois); David Specca (Rutgers); Dr. Ralph Hall (VT); Dr. Ron Meyers (VT); Dr. Fathel (PSU); Dr. Ciolkosz (PSU); Dr. Cundiff (VT); John Ignosh (VT)

- 9:30-10:00 Welcome
- 10:00-11:30 Educational Tour (Energy Efficiency) (Community Housing Partners Energy Solutions Research and Training Center: 550 Industrial Dr NE, Christiansburg, VA 24073)
    - Pictures from Site Visit: https://photos.app.goo.gl/Xdf4zrL82FsHNfXBA
    - Topics:
        - Regional Greenhouse Gas Initiative (RGGI) in VA
            - https://www.dhcd.virginia.gov/hiee
        - Energy Efficiency
            - Low Income Weatherization/Appalachia
                - https://youtu.be/6VaF6GO0W-8
        - Training Approaches
            - https://www.communityhousingpartners.org/energy-solutions/research-training-center/
            - Geographic Footprint

        - Demos (House of Pressure; Heat, Air, Moisture House)
- 11:40-12:00 Restoration Bioproducts Jeff Waldon, https://www.restorationbio.com/ (via ZOOM)
- 12:00-12:30 Biofuels in the Piedmont Presentation and Discussion, Dr. John Cundiff (in person):
    - LINK TO PDF OF SLIDES
    - Referenced Articles:
        - Resop, Jonathan P., John S. Cundiff, and Robert D. Grisso. 2022. "Central Control for Optimized Herbaceous Feedstock Delivery to a Biorefinery from Satellite Storage Locations" *AgriEngineering* 4, no. 2: 544-565. https://doi.org/10.3390/agriengineering4020037
        - Cundiff, John, Robert "Bobby" Grisso, and John Fike. 2020. "Feedstock Contract Considerations for a Piedmont Biorefinery" *AgriEngineering* 2, no. 4: 607-630. https://doi.org/10.3390/agriengineering2040041
- 12:30-1:00 Lunch Delivered

IN-PERSON & REMOTE NECC MEETING 1:00 PM - 3:30 PM

- Participants:
    - Via ZOOM: Dr. Lansing & Dr. Schiavone (Maryland); Dr. Joshi & Charles Gould (MSU); Dr. Yang (Connecticut); Robert Coville (Cornell)
    - In Person: Dr. Wang (Illinois); David Specca (Rutgers); Dr.Mehrizi-Sani (VT;) Dr. Ralph Hall (VT); Dr. Ron Meyers (VT); Dr. Fathel (PSU); Dr. Ciolkosz (PSU); Dr. Cundiff (VT); John Ignosh (VT)
- 1:00-3:30 NECC 2001 Meeting
    - Review and approval of previous meeting minutes
        - Shared via Google Doc for Review and Input LINK
    - Station Reports - (each university to give short summary of year's accomplishments)
        - Michigan State University
            - Recapped variety of proposal efforts related to renewable energy
            - Shared impacts from new extension publication on solar siting issues
        - University of Maryland
            - Highlighted efforts regarding a variety of solar energy and anaerobic digestion extension programming
            - See slides
        - Penn State University
            - Shared a description of core-programming and sponsored project work related to bioenergy projects with biochar, digestion of dedicated energy crops, pelletization
            - See slides
        - University of Illinois
            - Shared description of on-campus energy projects being used for energy generation and leveraged for research, including agrivoltaic system
            - See slides

        - University of Connecticut
            - Highlighted research and extension efforts related to controlled environment agriculture in urban areas with a “Green Box System”
            - Work explored technical and financial feasibility across 17 cities in different regions of US and to compare Green Box to greenhouse production systems
        - Virginia Tech
            - Described air emission project work related to on-farm poultry litter-to-energy system, new techno-econ analysis project; utility-scale solar issues; and temporary solar-powered water pumping systems for tenant farmers
            - See slides
        - Rutgers University
            - Provided an update on agrivoltaic project work in NJ
            - See slides
    - Discussion of Team Progress and Plans
        - Agrivoltaics Discussion (David Specca, Rutgers)
            - Discussion of racking and module suppliers; Charles Gould shared the website for the Florida vertical bifacial company https://www.et-sun.com/.
            - See Rutgers Slides
        - General discussion regarding potential interest in possibly expanding duration of future NECC meetings to 1-2 days to allow more time for discussion across diverse themes
    - Selection of Officers and Meeting Site for Next Year
        - David Specca, Rutgers selected as new co-lead (with co-lead Ignosh, VT) in 2023 with the intent that the NECC 2001 Annual Meeting will be hosted in NJ
- 3:30 Adjourn

ACCOMPLISHMENTS

The objectives of this regional project are to:

1. Prepare a survey report on the "regional farm energy status and outlook"
2. Identify research, education, and extension opportunities and needs for the topic of farm energy
3. Prepare joint proposals for funded projects in farm energy research, education, and Extension

Annual accomplishments are reported for each experiment station.

EXPERIMENT STATION: CONNECTICUT

Objective 1: Survey Report

No accomplishments to report.

Objective 2: Identify Opportunities

The Storrs Agricultural Experiment Station at University of Connecticut has supported studies on sustainable farm energy production and use. The current study focuses on the development of the so-called GREENBOX technology for urban agriculture. Specific objectives include

1. To determine whether the GREENBOX can provide the required environmental conditions year around;
2. To determine how the energy and water use as well as plant growth in the GREENBOX system in comparison with that in a greenhouse; and
3. To assess the financial feasibility of the GREENBOX.

Laboratory studies and analysis have been conducted in the past three (3) years at Storrs, Connecticut with protocol GREENBOXES and experimental greenhouses for growing lettuce. Results indicate that the newly proposed GREENBOX system can produce healthy lettuce crops in all four seasons with high productivity. The energy and water use are more effective compared to widely used glasshouses, and the inside environment conditions are much less variable. The benefit-cost analysis revealed that GREENBOX is financially feasible over various scenarios of different input parameters and can be used in major cities across the United States. The GREENBOX system can be used individually, or in any combination from a few to a very large number (say thousands) to meet different building configurations and economic goals. We find that the GREENBOX system is technically and financially feasible and can be used to produce fresh vegetables in urban areas with less resources and more control technologies.

Objective 3: Joint Proposals

A new proposal entitled “GREENBOX horticulture: A simulation study for optimization in system design and operation” has been funded by USDA Hatch funds.

EXPERIMENT STATION: ILLINOIS

Objective 1: Survey Report

No accomplishments to report.

Objective 2: Identify Opportunities

Construction of a new 54-acre, 12.32 MW(dc) Solar Farm 2.0 was started in July 2020. The overall project was completed by the end of 2020 and it has been operational since January 2021. Solar Farm 2.0 produced approximately 19,467 MWh in the first full year (6/30/21-6/30/22). All of the electricity generated by Solar Farm 2.0 are used exclusively by the Urbana campus, making the University of Illinois the third-largest user of renewable power produced on campus for all higher education facilities in the entire country.

Other innovative features of Solar Farm 2.0 include the incorporation of a pollinator habitat located beneath the panels. Indigenous plants will be planted throughout the farm to welcome local and migratory birds and insects. Specifically targeted towards butterflies and bees, Solar Farm 2.0 will be a welcoming environment for wildlife, as well as being a demonstration site for meeting the requirements of the Pollinator Friendly Solar Site Act.

A U of I extension team wrapped up the Smart Meter/ Energy Efficiency Education grant at the end of 2021. The project had been funded for calendar years 2017, 2018, 2019, 2020 and 2021. The goal had been to increase energy and smart grid knowledge across the state. Hard to reach low-income, seniors, and rural residence were defined as the primary audience for this statewide effort.

A team comprised of two campus researchers and two extension staff members continued the work on an Extension Collaboration Grant for a geothermal information project. The project goal is to develop a technical and outreach program that supports wider adoption of geothermal energy systems in Illinois. A decision support tool to assist decision makers and stakeholders in implementing geothermal energy for long-term solutions is currently under final stages of development. The decision support tool will link existing geological data at the university to industry design systems improving system performance while reducing initial cost in many cases. The group hosted several one hour webinars about various aspects and opportunities for geothermal as part of this project. The team plans additional webinars and in-person seminars as part of the rollout of the decision tool and associated web pages.

A $10 million, four-year project - SCAPES (Sustainably Colocating Agricultural and Photovoltaic Electricity Systems) was funded through the USDA's National Institute of Food and Agriculture (NIFA) Sustainable Agriculture Systems program. This project will study agrivoltaics in a variety of land types and climate scenarios (Illinois, Colorado, Arizona). It is led by Institute for Sustainability, Energy, and Environment (iSEE) at the University of Illinois. SCAPES project will provide a comprehensive analysis of the transformative potential of agrivoltaics. The goal is to maintain or even increase crop yield, increase the combined (food and electricity) productivity of land, and diversify and increase farmers' profits with row crops, forage, and specialty crops across a range of environments.

Objective 3: Joint Proposals

None

EXPERIMENT STATION: MICHIGAN

Objective 1: Survey Report

No accomplishments to report.

Objective 2: Identify Opportunities

A variety of needs-based extension and on-farm research work related to farm energy issues have been identified and events organized/planned. For example,

- MSU extension is organizing a conference "Michigan Ag Ideas to grow " with education sessions planned on several ag-voltaic topics including: Agrivoltaics – the future of farming?, Pollinator habitat in solar energy sites, and Conservation cover in solar energy sites.
- A report titled "Planning & Zoning for Solar energy Systems: A guide for Michigan local governments," was published.
- Implementation of 6th USDA-REAP Energy Audit/Renewable Energy Assessment project.
- Offering no-cost farm energy audits in partnership with cost share from Michigan Utilities.
- Field testing of a prototype system to mitigate the huge start-up energy draw of large electric motors and improve energy efficiency in motors with a low-cost alternative to variable frequency drives.
- Consultations with industry and state entities in response to a Dept of Energy (DOE) needs identification for current and future solar workforce training.
- Participation in Michigan Agricultural Energy Council (MAEC), in providing a trusted "third party" platform that brings farm organizations and utilities together to tackle energy issues and challenges facing the agricultural sector.
- Charles Gould was a member of the organizing committee for the 2022 National Extension Conference on Energy Efficiency.

Objective 3: Proposals

A number of proposals/ preproposals were submitted during this period but unfortunately, none were funded.

- Joint pre-proposal with Virginia Tech titled "Agrivoltaics in Virginia for Existing and Future Utility-scale PV: Applying, Developing, and Expanding the Adoption of New Practices " submitted to DOE Foundational Agrivoltaic Research for Megawatt Scale (FARMS) RFP
- MSU preproposal titled "System-scale Optimization of Commercial Agrivoltaic Solutions for Pasture-based Dairy Farms" to DOE Foundational Agrivoltaic Research for Megawatt Scale (FARMS) RFP
- MSU proposal titled "Sustainable agricultural mobility technology for specialty crop production," submitted to Michigan Economic Development Corporation
- MSU proposal titled "Solar Energy Systems for Sustainable Fruit and Vineyard Production in Michigan," submitted to Project GREEEN.

EXPERIMENT STATION: NEW JERSEY

Objective 1: Survey Report

Two book chapters titled “Energy Efficiency - Greenhouse Energy Management” and “On-Farm Energy Production - Solar, Wind, Geothermal” were published as part of our committee’s efforts to report on the regional farm energy status and outlook.

Objective 2: Identify Opportunities

The Rutgers Agrivoltaics Program has been approached by the NJ Board of Public Utilities (NJBPU) about an advisory role the program can have with regard to the state mandated Dual-Use Pilot Program (i.e., agrivoltaics). The NJBPU is looking for expert input for the design and implementation of this three-year 200 MW program (extendable to five years and up to 300 MW).

Objective 3: Proposals

The Rutgers Agrivoltaics Program submitted a $2M proposal to the US Department of Energy FARMS program. The proposal was a joint effort in collaboration with American Farmland Trust, Delaware State University and the National Renewable Energy Laboratory. Whether our proposal will be recommended for funding is unknown at the time of writing.

The NJBPU is also soliciting a proposal from the Rutgers Agrivoltaics Program to conduct research at the Pilot Program farms because it is mandated in the regulations that University-based research be performed as part of the Pilot Program.

EXPERIMENT STATION: PENNSYLVANIA

Objective 1: Survey Report

The volume has been published by Springer Science as an academic book. Contents consist of the following:

1. Energy Use on the Farm
   D. Ciolkosz, A. Go
2. Energy Efficiency - Smart Metering
   E. Johnstonbaugh, X. Wang
3. Energy Efficiency - Equipment Use and Installation
   S. Sanford, A. Go
4. Energy Efficiency - Field Operations
   S. Sanford, A. Go
5. Energy Efficiency - Dairy Operations
   S. Sanford, A. Go
6. Energy Efficiency - Livestock Housing Operations
   S. Sanford, A. Go
7. Energy Efficiency - Fruit and Vegetable Storage

S. Sanford, A. Go

8. Energy Efficiency - Grain Drying
   S. Sanford, A. Go
9. Energy Efficiency - Irrigation
   S. Sanford, A. Go
10. Energy Efficiency - Maple Syrup
    S. Sanford, A. Go
11. Energy Efficiency - Greenhouses
    A. Both
12. On-Farm Energy Production - Solar, Wind, Geothermal
    A. Both
13. On-Farm Energy Production - Biomass Thermal
    E. Johnstonbaugh
14. On Farm Energy Production - Biogas
    A. Hassanein, S. Lansing, E. Keller
15. On-Farm Energy Production - Biofuels
    D. Ciolkosz, M. Steiman

Penn State's component included overall editing of the volume and authorship or co-authorship of chapters 1, 2, 13 and 15.

Objective 2: Identify Opportunities

The topic of sustainable farm electrification has cropped up as a topic of potential value for investigation, and will be broached at the 2022 team meeting.

Objective 3: Joint Proposals

Team members participated in several project proposals:

- Willow Debarking (D Ciolkosz): USDA AFRI, two proposals were submitted, teaming with SUNY ESF (Kumar, Volk). Proposed research on processing of short rotation willow.
- Mushroom Energy and Carbon (D Ciolkosz): USDA NIFA. Proposed research and extension on developing carbon-neutral strategies for mushroom farming.
- Biogas in the Ukraine (D Ciolkosz): CRDF. Proposed support of development of a biogas research effort at university in Ukraine.
- BMPs for Solar Farm Development (S Fathel): NFWF. Proposed online course for Chesapeake Bay-targeted best management practices in solar farm development, submitted with VA Tech (Ignosh).

Other accomplishments that do not necessarily relate to the NECC-1501 Multistate Research Project objectives:

Wood Innovation Grant (Johnstonbaugh, Ciolkosz, Musgrave): Penn State Extension continued pursuing a demonstration test of biochar addition to a municipal wastewater treatment plant.

MASBio (Ciolkosz, Johnstonbaugh, Musgrave, Wurzbacher): In this AFRI CAP project, involving multiple institutions, extension, research and education efforts were launched related to biomass production on marginal lands, and biochar manufacture. Energy is a component of this effort, but not the primary focus.

C-Change Grass to Gas (Ciolkosz, Fathel, Johnstonbaugh): In this AFRI CAP led by Iowa State, education, extension and research efforts were undertaken to develop scenarios for enhanced biogas production from the use of perennial grasses, grown in ecologically strategic locations on farms.

National Energy Extension Summit (Ciolkosz, Johnstonbaugh, Wurzbacher): Penn State hosted the National Energy Extension Summit / National Sustainability Summit on May 15-18 2022 in State College, PA. Many NECC-2001 committee members were involved in the planning of this event.

Student Research: Completed and ongoing student research projects of relevance to Farm Energy Production and Use include:

- Wheat Straw Torrefaction and Conversion (B Memis, J Tripathi, D Ciolkosz)
- Biomass Sorption (A Arya, J Tripathi, D Ciolkosz)
- Biomass Pelleting (Y Li, K Lopez, D Ciolkosz)
- Biogas from Cellulosic Feedstock (M McVey, D Ciolkosz)
- Biomass pelleting of ag waste (M Asif, D Ciolkosz)

Support for these projects was provided by ongoing grants, College of Agricultural Science research funds, and the Graves Extension Endowment.

Farm Energy Course (Fathel): Course which focuses on biorenewable energy sources derived from farms at Penn State University. A key component of this course is a semester long energy audit project, wherein teams of students perform energy audits local farms or businesses following ASABE Standards. This is a required course for undergraduate students in the BioRenewable Systems major.

EXPERIMENT STATION: MARYLAND

Objective 1: Survey Report

No accomplishments to report.

Objective 2: Identify Opportunities

The Maryland team has been working with on-farm energy efficiency and conservation.

- The Maryland team facilitated a series of hands-on training and educational workshops throughout Maryland to support a documented need for energy education in Maryland related to on-farm solar photovoltaics (PV) or agricultural solar. A total of 179 farmers

and agricultural service providers participated in one of the ten educational workshops to learn about the options, opportunities and challenges associated with on-farm solar PV to support farm sustainability. Training addressed the basic principles of solar PV technology; an exploration of appropriate on-farm applications; the basic principles of electricity, PV components, and system design; and an overview of solar contracts and leasing options relevant to Maryland farmers.

- The Maryland team is producing supplemental training videos, and a series of related factsheets, to support hands-on training with solar PV. A total of 17 videos have been produced in this series with 88,000 views in total. These resources explore various tips and tools for working with solar photovoltaics, including an overview on how to assess solar module output; load and site assessments; wiring and OCPDs; series and parallel configurations; battery backup; and inverter integration.

The University of Maryland team has been working with farmers in implementing anaerobic digestion technology for dairy and poultry famers, as well as biochar production from poultry manure.

- The Maryland team has worked with a dairy farm in Cecil County, MD to monitor their anaerobic digestion manure and food waste co-digestion system with solid separation and composting. Future extension efforts will focus on helping farmers navigate power purchase agreements and understanding opportunities with food waste co-digestion. Work funded under Maryland Department of Agriculture.
- The Maryland team is evaluating the feasibility of animal waste technologies, including anaerobic digestion, gasification, pyrolysis, and will assess greenhouse gas emissions associated with these technologies, barriers to adoption, market assessments of their feasibility, and how to incorporate environmental justice in project citing, implementation, and operation. Work funded under Maryland Department of Agriculture.
- The Maryland team is conducting a study using poultry litter biochar for plant production and understanding the markets and sustainability associated with biochar utilization. Specifically, the project is looking at ornamental plant production using biochar to replace phosphorus fertilizer and growing turf grass with biochar amendments.
- The Maryland team is providing third-party verification for a digestion system on the Maryland Eastern Shore that is piloting a poultry litter-based, solid-state digestion systems conducted as a batch process, with post-digestion nutrient recovery. Work funded under Maryland Energy Administration.
- The Maryland team is working on reducing antimicrobial resistance through integration of engineering and social science, Dr Lansing team lead a multi-million USDA grant that developed a new method for antibiotic detection in manure and determined the effect of advanced treatment technologies, such as anaerobic digestion and composting, on resistance. Work funded under USDA-NIFA.

Objective 3: Proposals

- None

EXPERIMENT STATION: VIRGINIA

Objective 1: Survey Report

No accomplishments to report.

Objective 2: Identify Opportunities

A variety of needs-based extension and on-farm research work related to farm energy issues have been identified, including through the following sponsored projects:

- Mountains to Bay Grazing Alliance: Technology Transfer for Transportable Solar-Powered Water Pumping Systems, Sub-award from Chesapeake Bay Foundation. National Fish & Wildlife Foundation 11/18-12/22
- "A Better Solar "Panel" from Virginia Tech", CALS – Virginia Tech 3/21-6/22
- "Keeping on the Sunny Side with On-Farm Solar Applications", Virginia Department of Mines, Minerals and Energy, 4/1-6/23
- "Techno-Economic Analysis for On-farm Poultry Litter-to-Energy Systems", Conservation Innovation Grant - Pennsylvania NRCS. 8/22-8/25

Objective 3: Proposals

- Joint pre-proposal with Michigan State University titled "Agrivoltaics in Virginia for Existing and Future Utility-scale PV: Applying, Developing, and Expanding the Adoption of New Practices" submitted to DOE Foundational Agrivoltaic Research for Megawatt Scale (FARMS) Concept Note (not funded)

IMPACTS

1. EXPERIMENT STATION: Connecticut
   Rising urbanization, increasing global population, and increasing strain on the food supply chain have increased the threats to our food supply. Now more than ever, we need methods to intensify food production to meet our food needs without further degrading the environment. Urban areas with high population concentrations are heavily dependent on foods that have traveled long distances to meet their needs which represented resources wasted on movement and significant carbon emissions. In the face of the worldwide population increase and urbanization, the Yang lab at the University of Connecticut has developed the GREENBOX technology for massive vegetable production in urban settings. We aim to create a true plant factory (like an assembly line production of food) in close proximity to urban centers by utilizing low-cost warehouse spaces to house standardized, stackable, and individually controlled GREENBOXES at variable scales. A medium to large-scale GREENBOX setup represents a significant reduction in carbon emission associated with food transport and eliminates the need for food transportation and storage. Each GREENBOX consists of a thermally insulated enclosure with an artificial lighting element and an environmental control system, which renders it independent from the requirement of open spaces and exposure to the sun. GREENBOX

systems can produce different crops or at different stages for a continual supply. Because the warehouse environment is less affected by external weather variations, the GREENBOX systems use less energy and water than a traditional greenhouse and, therefore, the technology has high potential to be widely applied in fresh food production in urban areas. We have delivered several presentations at professional meetings and seminars for potential supporting agencies and collaborators. One refereed journal articles has been published and three more have been submitted for publication.

2. EXPERIMENT STATION: Illinois
   The smart meter/ energy efficiency education project involved eight U of I extension educators from across the state. Over the last five years, the extension team has conducted 193 events directly reaching 5564 residents across Illinois. These events include in-person presentations, youth hands-on activities, and statewide/local webinars, The recordings of these webinars have been posted to the U of I YouTube channel. The geographic reach included 41 counties in across northwest, central and southern Illinois. The events included statewide and regional webinars and web posted recordings that likely attracted participants from additional counties not included in the zip code data analysis.

3. EXPERIMENT STATION: New Jersey
   NJ has ambitious renewable energy goals and has a history of promoting photovoltaics. A logical option would be to allow for more solar farming. However, solar farming typically takes the land out of agricultural production. In a small and densely populated state like NJ, that is a less attractive option. Raising the photovoltaic panels on taller posts and reducing their density would allow for a combination of agricultural production and electricity generation with photovoltaic panels. The NJ Agricultural Experiment Station and the state legislature have provided over $2M of funding to a team of researchers to develop a number of research and demonstration facilities at three university farms across the state. The team is planning to construct these facilities over the next year and will conduct experiments involving field and forage crop trials. Long-term, the impact from our efforts will assist farmers, Extension professionals, solar developers, and regulators with research-based information about agrivoltaics. The dual-use/agrivoltaics program can make a substantial contribution to the NJ's Global Warming Response Act goal of 100% clean energy by 2050.

4. EXPERIMENT STATION: Pennsylvania
   Presentations, written materials, on-site demonstrations, and responses to inquiries have been provided on farm energy production and use.

5. EXPERIMENT STATION: Maryland
   New manure management energy systems are being installed in Maryland farms with expertise from Maryland Extension on operation and quantifying functional parameters of waste to energy. Transformations of nutrients, antibiotics, as well as energy production efficiency, are being quantified in manure to waste technologies used on-farm by the University of Maryland team, with on-going material content (Fact Sheets and articles) being produced and new on-farm workshops and tours being conducted. Additionally, we are conducting a state-wide assessment on the animal waste resources in Maryland, and the effect of manure transfer technologies, including digestion and gasification, for renewable energy production, reductions in greenhouse

gas emissions, increased farm economic vitality, and policy change implications. In addition, Maryland team created a chapter entitled, "On Farm Energy Production – Biogas," which provides farme's with a complete guide to understanding digester implementation on-farm. We are also conducting assessments of utilized poultry litter-derived biochar for plant growth and poultry litter digestion conducted as a bathc process with post-digestion nutrient recovery. Solar photovoltaic (PV) systems are being installed in Maryland farms with expertise from Maryland Extension on design and installation through on-going production of material content (Fact Sheets, handbook, curriculum, articles), virtual programs (webinars, training videos, design tools), and new in-person events (workshops, consultations). Relevant educational programs have included 3 lectures/presentations, 10 workshops/demonstrations, and 25 one-on-one consultations to reach a total 385 individuals. An additional 88,531 views have been reported for on-demand recordings and training videos.

6. EXPERIMENT STATION: Michigan
   Educational materials and reports have been widely circulated through websites, webinars, and training programs. 10 energy audits and 3 renewable energy assessments were carried out free of cost. All of them have applied for USDA-REAP grants. MSU's energy audit certification recognized by ASABE/ANSI, USDA RD and NRCS as well as the only energy audit accepted by Michigan Utilities under their farm audit rebate program.

7. EXPERIMENT STATION: Virginia
   Design and Siting Considerations for Transportable Water Pumping Stations for Livestock Watering Systems on Rented Pastures in the Chesapeake Bay Watershed: Beef cattle represent Virginia's second largest agricultural commodity and approximately one-third of Virginia farmland is rented pasture. The Chesapeake Bay TMDL and Virginia's Watershed Implementation Plan, sets forth a series of sector-specific best management practices including additional fencing to exclude livestock from streams. For some of these pastures, additional fencing may require alternative livestock watering systems. The cost to extend the electrical grid to power a small water pump may prove to be prohibitively expensive for some locations. Furthermore, the installation of capital-intensive livestock watering improvements can be problematic on rented acreage with annually renewable leases. Utility-scale Solar Project Development in Virginia: Informational Series: The Virginia Clean Economy Act of 2020 stipulates that by 2045 all electricity must be from renewable energy and targets development of 16GW for renewables and 3GW of energy storage. Currently, and into the near future, much of this energy project development is proposed to occur as USS projects. Virginia USS capacity is currently 1GW with an average USS footprint of 10.4 acres/MW. Across Virginia, many projects have been developed and many more proposed, often with mixed reactions across the communities. An informational webinar series was developed to help answer stakeholder questions. The 9-webinar series has included more than 700 registrants, including participants from landowners, state agencies, researchers, project developers from industry, utility companies, county planners/Board of Supervisors, non-governmental organizations, among many others to share information, resources, lessons learned, and emerging best practices for utility-scale solar project development in Virginia. 80% of respondents indicate that their awareness of issues regarding utility-scale PV projects in Virginia increased. Artifacts from these sessions, along with related educational resources, are now hosted on a website for asynchronous access. Additional collaborations and project proposals are underway to provide a deeper

response to the issues, opportunities, challenges, and remaining knowledge gaps of utility-scale solar project development in Virginia.

PUBLICATIONS

EXPERIMENT STATION: Connecticut

Dissertations, Theses (Published)

1. Ankit Kumar Singh, 2022. GREENBOX Technology for Urban Crop Production: Technical Performance and Financial Feasibility. PhD dissertation, University of Connecticut, Storrs, CT

Non-Refereed Conference Publications (Published)

1. Singh, A.K. and **X. Yang**, 2022. Financial feasibility of GREENBOX technology for urban crop production. ASABE Paper No. 2201068. ASABE, St. Joseph, MI

Refereed Journal Articles (Published)

1. Singh, A.K. and X. Yang, 2021. GREENBOX horticulture, an alternative avenue of urban food production. Agricultural Sciences 12: 1473-1489

EXPERIMENT STATION: Illinois

Books (Published)

- Ciolkosz (Ed.): Regional Perspectives on Farm Energy, Springer Nature. Switzerland AG. ISBN 978-3-030-90830-0.

Book Chapters (Published)

- Johnstonbaugh E. and Wang X. 2022. Energy Efficiency – Smart Metering. In: Ciolkosz (Ed.): Regional Perspectives on Farm Energy, Springer Nature. Switzerland AG. ISBN 978-3-030-90830-0. pp.15-18.

Refereed Journal Articles (Published)

- Z. Zhao, Y. Lin, A. Stumpf, X. Wang, Assessing impacts of groundwater on geothermal heat exchangers: A review of methodology and modeling, Renew. Energy 190 (2022) 121147. https://doi.org/10.1016/j.renene.2022.03.089.

EXPERIMENT STATION: New Jersey

Book Chapters (Published):

- Both, A.J. 2022. Greenhouse energy efficiency and management, Chapter 11. In *Regional Perspectives on Farm Energy* (D. Ciolkosz, Ed.). Springer, Switzerland. pp. 85-93.
- Both, A.J. 2022. On-farm energy production – Solar, wind, geothermal, Chapter 12. In *Regional Perspectives on Farm Energy* (D. Ciolkosz, Ed.). Springer, Switzerland. pp. 95-105.

Refereed Journal Articles (Published):

- Lewus, D.C. and A.J. Both. 2022. Using computational fluid dynamics to evaluate high tunnel roof vent designs. *AgriEngineering 4*(3), 719-734; https://doi.org/10.3390/agriengineering4030046
- Lubna, F.A., D.C. Lewus, T.J. Shelford, and A.J. Both. 2022. What you may not realize about vertical farming. Horticulturae 8(4), 322. https://doi.org/10.3390/horticulturae8040322
- Shelford, T.J. and A.J. Both. 2021. On the technical performance characteristics of horticultural lamps. AgriEngineering 3:716-727. https://doi.org/10.3390/agriengineering3040046

Abstracts of papers presented at professional meetings (Published):

- Birnie, D., W.R. Rucker, and A.J. Both. 2022. Comparison of sunlight shadow patterns and photovoltaic energy yields for various agrivoltaic array designs. ASA, CSSA, SSSA International Annual Meeting, Baltimore, MD. https://scisoc.confex.com/scisoc/2022am/meetingapp.cgi/Paper/144722
- Lubna, F.A. and A.J. Both. 2022. Assessing the environmental impacts of supplemental lighting for crop production across the United States. ASHS Annual Conference, Chicago, IL. HortScience 57(9) Supplement (Part 1), S63. https://journals.ashs.org/hortsci/view/journals/hortsci/57/9S/article-pS1.xml
- Brumfield, R.G., S. Arumugam, A.J. Both, M. Flahive Di Nardo, R. Govindasamy, D. Greenwood, J. Heckman, N. Polanin, A.A. Rouff, A. Rowe, and R. VanVranken. 2021. A successful educational program for women producers, beginning farmers, and military veterans that helped address farm risks during the COVID-19 pandemic. Presented at the 2021 Annual Conference of the American Society for Horticultural Science (ASHS), Hybrid, Denver, CO, August 5-9. HortScience 56(9) Supplement, S61.

Refereed Symposium Proceedings Articles (Published):

- Llewellyn, D., T.J. Shelford, Y. Zheng, and A.J. Both. 2022. Measuring and reporting lighting characteristics important for controlled environment plant production. Acta Horticulturae 1337:255-264.
- Shelford, T., A.J. Both, and N. Mattson. 2022. A greenhouse daily light integral control algorithm that takes advantage of day ahead market electricity pricing. Acta Horticulturae 1337:277-282.

Popular (Trade Journal) Articles (Published):

- Both, A.J. 2022. A quick look into LEDs. GrowerTalks. April Issue. pp. 50-51.

Other Creative Works:

- Both, A.J. and N. Mattson. 2022. What to expect when you're selecting? Light systems and economics. Presentation at Cultivate'22, Columbus, OH. July 19.
- Both, A.J. 2022. Review of greenhouse energy issues. Online presentation for the Greenhouse Grower School (Cornell Cooperative Extension of Orange County). February 9.

- Both, A.J. 2022. Hydroponics. Online presentation for students at the Sojourner Truth Middle School, East Orange, NJ. January 28.
- Both, A.J. 2022. Greenhouse design. Online presentation for the 5th Annual Urban Farmer Winter Meeting (University of Maryland Cooperative Extension). January 24.
- Both, A.J. 2021. Sustainable crop production. Online presentation for students at Delaware Valley University. December 7.
- Both, A.J. 2021. Energy conservation strategies for greenhouse crop production. Presentation at the Northeast Greenhouse Conference and Expo. Boxborough, MA. November 4.
- Both, A.J. 2021. Focusing on sustainability: Crop production, soils and energy (Agrivoltaics as a solution?). Presentation for Annie's Project New Jersey: 10 Years of Empowering New Jersey Farmers. New Brunswick, NJ. November 4.
- Both, A.J. 2021. Are LED lamps better for crop production in greenhouses? Narrated PowerPoint presentation for the Energy Answers for the Beginning Farmer and Rancher Project. Available at: https://farm-energy.extension.org/energy-answers-for-the-beginning-farmer-and-rancher/
- Both, A.J. 2021. How can we improve energy efficiency in greenhouses? Narrated PowerPoint presentation for the Energy Answers for the Beginning Farmer and Rancher Project. Available at: https://farm-energy.extension.org/energy-answers-for-the-beginning-farmer-and-rancher/
- Both, A.J. 2021. What alternative energy systems can be used in the greenhouse industry? Narrated PowerPoint presentation for the Energy Answers for the Beginning Farmer and Rancher Project. Available at: https://farm-energy.extension.org/energy-answers-for-the-beginning-farmer-and-rancher/
- Specca, D.R. 2021 Agrivoltaics/Dual Use Solar: A Win-Win for Ag Viability? Narrated PowerPoint presentation for the NJ Farm Bureau Delegates at their Annual Convention. November 15.
- Specca, D.R. 2022 Clean and Renewable Energy Options for NJ Homes and Businesses. Presentation to the NJAES Environmental Stewards Class. March 1.
- Specca, D.R. 2022 The Rutgers Agrivoltaics Program. Presentation to the Agriculture and Natural Resources Department, NJ Agricultural Experiment Station. March 25.

Workshop Sponsor:

- Both, A.J., D. Specca, D.P. Birnie, and K.P. Sullivan. 2022. Agrivoltaics. Information session at the 67th New Jersey Agricultural Convention and Trade Show. February 8-10.

Workshop Participant:

- Specca, D. and A.J. Both. 2022. National Extension Energy Summit combined with the National Sustainability Summit. Penn State University. May 15-18.

Refereed Journal Articles (Pending):

- Brumfield, R.G., M. Flahive Di Nardo, A.J. Both, J. Heckman, A. Rowe, R. VanVranken and M. Bravo. 20xx. Online workshop empowers women farmers to manage business risk during the pandemic. Accepted for publication in Acta Horticulturae.

EXPERIMENT STATION: Pennsylvania

Books (Published)

- Ciolkosz, D. (ed.): Regional Perspectives on Farm Energy. Springer Nature Switzerland AG. ISBN 978-3-90830-0. pp. 1-14.

Book Chapters (Published)

- Ciolkosz, D., and Go, A. 2022. Energy Use on the Farm. In: Ciolkosz (ed.): Regional Perspectives on Farm Energy. Springer Nature Switzerland AG. ISBN 978-3-90830-0. pp. 1-14.
- Ciolkosz, D., and Steiman, M. 2022. On-Farm Energy Production: Biofuels. In: Ciolkosz (ed.): Regional Perspectives on Farm Energy. Springer Nature Switzerland AG. ISBN 978-3-90830-0. pp. 139-148.

Refereed Journal Articles (Published)

- Tripathi, J., Richard, T. L., Memis, B., Demirci, A., & Ciolkosz, D. (2022). Interactions of Torrefaction and Alkaline Pretreatment with Respect to Glucose Yield of Hydrolyzed Wheat Straw. Biomass, 2(4), 264-278.
- Chahal, A., Tripathi, J., Ciolkosz, D., Wurzbacher, S., and M. Jacobson. 2021. Perceptions of Debarking Small Stems in the Wood Products Community. Forest Products Journal. 71(4): 371-378. https://doi.org/10.13073/FPJ-D-20-00074
- Herbstritt, S., Fathel, S. L., Reinford, B., Richard, T. L. 2022. Waste to Worth: A Case Study of the Biogas Circular Economy in Pennsylvania. Journal of ASABE. doi: 10.13031/ja.14889.

Popular Articles (Published)

- Ciolkosz, D. 2022. Anaerobic Digesters for Renewable Natural Gas. Penn State Renewable and Alternative Energy Fact Sheet Series. The Pennsylvania State University. University Park, PA.
- Miller, A. 2022. How to Choose a Solar Panel (Photovoltaics) Vendor. Penn State Extension Online Article. Published July 8, 2022
- Brockett, D. 2022. Pennsylvania Landowners Guide to Utility-Scale Solar Leasing. Penn State Extension Online Article. Published April 22, 2022
- Fathel, S. L. 2022. How Pennsylvania Biogas Can Participate in the Energy Marketplace. Penn State Extension Online Article. Published January 14, 2022.

Presentations (Papers)

- Tripathi, J., and Ciolkosz, D. 2022. Techno-Economic Analysis of Wheat Straw-Based Ethanol System Consisting of Torrefaction and Alkaline Pretreatment Technologies.

Presented at ASABE International Meeting, July 19, 20122, Houston, TX.

- Tripathi, J., & Ciolkosz, D. 2022. Towards a Multiproduct BioRenewable Paper: Synergy of Torrefaction and Alkaline Pretreatment for Increased Utility. Presented at Penn State Biorenewables Symposium,, April 14, 2022, University Park, PA.
- Lopez-Olmedo, K., Ciolkosz, D., Frente-Carrasco, M., and Gomez-Hernandez, L. 2022. Wood Energy: An alternative for sustainable forest harvesting, Oaxaca, Mexico. Presented at Northeast Agricultural and Biological Engineering Conference. 310 Jul – 03 Aug 2022. Edgewood, MD.
- Asif, M., Farid, M., Ciolkosz, D., Ghafoor, A., Nasir, A., and Hussain, S. 2022. Development of Rotor Type Biomass Densification Machine for the Production of RDF Pellets from Agricultural Wastes and Crop By-Products. Presented at Northeast Agricultural and Biological Engineering Conference. 310 Jul – 03 Aug 2022. Edgewood, MD.
- Tripathi, J., Ciolkosz, D. 2022. Techno Economic Analysis of Wheat Straw Based Ethanol System Consisting of Torrefaction and Alkaline Pretreatment Technologies. Presented at Northeast Agricultural and Biological Engineering Conference. 310 Jul – 03 Aug 2022. Edgewood, MD.
- Fathel, S., Tripathi, J., & Ciolkosz, D. 2022 (Penn State University). Understanding the Role of Farm Energy in Extension Programs, National Extension Energy Summit + National Sustainability Summit 2022, Penn State University, University Park, PA.

Workshop Sponsor

Biogas Systems Webinar Series (222 live attendees, recordings available online), April 11-15, 2022:

(1) Understanding the Science of Biogas Production (https://extension.psu.edu/biogas-systems-in-pennsylvania-understanding-the-science-of-biogas-production)

(2) Ways to Profit from Anaerobic Digestion (https://extension.psu.edu/biogas-systems-in-pennsylvania-ways-to-profit-from-anaerobic-digestion)

(3) Carbon Markets for Biogas and Future Opportunities (https://extension.psu.edu/biogas-systems-in-pennsylvania-carbon-markets-for-biogas-and-future-opportunities)

(4) Types of Anaerobic Digestion Systems: Community, Poultry, Small-Scale and More (https://extension.psu.edu/biogas-systems-in-pennsylvania-types-of-anaerobic-digestion-systems-community-poultry-small-scale-and-more)

(5) Panel Discussion (https://extension.psu.edu/biogas-systems-in-pennsylvania-panel-discussion)

Other Webinars (recorded and available online at extension.psu.edu)

- Solar Law Symposium. November 16, 2022 (29 registrants)
- Open Solar Q&A for Series Participants. Aug 23, 2022 (283 registrants)
- Agrivoltaics and Solar Utility Considerations. Aug 9, 2022 (378 registrants)
- Estate Planning with Solar Leases. Jul 26, 2022 (219 registrants)

- Leasing Your Land for Solar Energy Development. Jul 12, 2022 (189 registrants)
- Solar Leasing Questions, Answers, and Wrap Up. Mar 23, 2022 (313 registrants)
- Evaluating Key Contract Terms When Leasing Your Land for Solar Energy Development. Mar 16, 2022 (286 registrants)
- Utility-Scale and Community Solar in New York and Pennsylvania. Feb 2, 2022 (444 registrants)

Webinars that were not recorded:

- A Conversation with Local Government Officials: Farmland Transitions to Grid-Scale Solar. January 18, 2022 (41 registrants)
- A Conversation with Local Government Officials: Utility-Scale Solar Toolkit. February 15, 2022 (58 registrants)
- A Conversation with Local Government Officials: Utility-Scale Solar Ordinances at the Local Government Level. March 15, 2022 (58 registrants)
- A Conversation with Local Government Officials: Issues at the Convergence of Agriculture and Utility-Scale Solar Energy. April 19, 2022 (34 registrants)
- A Conversation with Local Government Officials: Siting Considerations for Utility-Scale Solar in Pennsylvania Communities. May 17, 2022 (33 registrants)
- A Conversation with Local Government Officials: Utility-Scale Solar Toolkit. June 21, 2022 (31 registrants)
- Tools for Local Officials in Regulating Utility-Scale Solar Development. July 19, 2022 (17 registrants)
- A Conversation with Local Government Officials: Where We Are Now with Utility-Scale Solar in Our Communities. August 16, 2022 (29 registrants)
- Mapping Out Potential Solar Development and Decommissioning: Discussion Series for Local Officials. September 20, 2022 (23 registrants)
- A Conversation with Local Government Officials: Decommissioning Utility-Scale Solar – Concerns and Options. October 18, 2022 (17 registrants)

Refereed Journal Articles (Pending)

- Tripathi, J., and Ciolkosz, D. 2022. Torrefied paper as a packaging material and subsequently as a bioethanol substrate: Synergy of torrefaction and alkaline pretreatment for increased utility. Resources, Conservation and Recycling. Submitted for Publication.
- Valentin, M., Bialowiec, A., Karayel, D., Jasinskas, A., Ciolkosz, D., and Lavarias, J., 2022. Investigation of the Performance of a Cylindrical Hopper and Metering Device of a Carrot Seeder. Scientific Reports. Accepted pending revisions.
- Tripathi, J., Causer, T., Ciolkosz, D., DeVallance, D., and Nunes, L. 2022. Torrefied Biomass in the Bioeconomy. Renewable and Sustainable Energy Reviews. Submitted for Publication.
- Memis, B., Ciolkosz, D., Richard, T., and M. Hall. 2022. Impact of Alkali Pretreatment and Torrefaction on Glucose Production From Wheat Straw. Journal of the ASABE.

Accepted for Publication.

EXPERIMENT STATION: Maryland

Book Chapters (Published)

- Hassanein, A., **Lansing, S**., 2022. Boosting anaerobic digestion with microbial electrochemical technologies. In *Advances in Bioenergy*, pg 67-98. Elsevier. https://doi.org/10.1016/bs.aibe.2022.05.003.
- Hassanein, A., **Lansing, S**., Keller, E., 2022. On-farm energy production: Biogas. In Ciolkosz, D. (eds) *Regional Perspectives on Farm Energy*, pg 117-138. Springer, Cham. https://doi.org/10.1007/978-3-030-90831-7_14.
- Ferrer-Martí, I., **Lansing, S**., Marti-Herrero, J. (Eds), 2022. *Biogas for Rural Areas*. Printed edition of the special issue published in *Energies*. ISBN 978-3-0365-3236-3. Available at: https://www.mdpi.com/books/pdfdownload/book/5004.

Refereed Journal Articles (Published)

- Hassanein, A., Moss, A., Cloyd, N. Lansing, S*., 2022. Evaluation and life cycle assessment of a poultry litter anaerobic digester with nutrient capture. Bioresource Technology Reports 19, 101186. https://doi.org/10.1016/j.biteb.2022.101186.
- Hassanein, A., Kumar, A.N., Lansing, S*., 2021. Impact of electro-conductive nanoparticle additives on anaerobic digestion performance – A Review. Bioresource Technology 432, 126023. https://doi.org/10.1016/j.biortech.2021.126023.
- Holl, E., Steinbrenner, J., Merkle, W., Krumpel, J., Lansing, S., Baier, U., Oechsner, H., Lemmer, A*., 2022. Two-state anaerobic digestion: State of technology and perspective roles in future energy systems. Bioresource Technology 360: 127633. https://doi.org/10.1016/j.biotech.2022.127633.
- Nachod, B., Keller, E., Hassanein, A., Lansing, S*., 2021. Assessment of petroleum-based plastic and bioplastics degradation using anaerobic digestion. Sustainability 13(23): 13295. https://doi.org/10.3390/su132313295.
- Schiavone, D. F. (2022). Identifying Opportunities and Priorities for Energy Extension. The Journal of Extension, 60(3), 8.
- Schiavone, D. F., & Montross, M. D. (2021). Thermophysical Properties of Baled Switchgrass. Applied Engineering in Agriculture, 37(6): 1107-1114.

Extension Publications (Published)

- **Schiavone, D.** (2022). *A Brief Guide to On-Farm Solar*. The University of Maryland Extension, FS-1187.
- **Schiavone, D.** (2021). *Solar Panels are an Increasingly Common Sight on Urban and Rural Properties across Maryland*. The University of Maryland Extension, EB-455.
- **Schiavone, D.** (2021). *Maryland's Energy Market: The State Consumes More Energy than it Produces*. The University of Maryland Extension, FS-1188.

- **Schiavone, D.** (2022). *Energy Used in Homes, Businesses, and Farms is Typically Supplied as Heat or Electricity*. The University of Maryland Extension, EBR-63.

Invited Presentations (without Proceedings)

- Lansing, S., 2022. Bioenergy and bioprocessing technologies: Novel integrations in waste to energy applications. Taiwanese Council of Agriculture. College Park, Maryland. August 4, 2022.
- Lansing, S., 2022. Policies affecting anaerobic digestion implementation. Cecil County Land Trust Anaerobic Digestion Roundtable, with representatives from US Senate, MD legislators and MD Governor's office. Elkton, Maryland. October 7, 2022.
- Lansing, S., 2022. Co-Digestion on a Maryland Farm. Northeast Agricultural and Biological Engineering Conference (NABEC). Invited Presentation and Tour, Rising Sun Maryland. August 3, 2022.
- Lansing, S., 2022. Transforming food waste to energy through anaerobic digestion. Colorado Mesa University Environmental Science Seminar Series (virtual). April 25, 2022.
- Lansing, S., 2022. Quantifying Cattle Manure-AMR Perceptions and Treatment System Variabilities to Develop a Novel Communication Framework for Conveying AMR Science and Mitigation Opportunities. USDA NIFA – Antimicrobial Resistance (AMR) FY 2022 Project Director's Meeting (virtual). March 16, 2022.
- Lansing, S., 2022. Policy strategies to build resilience in Maryland's food system (moderator), AGNR Sustainable Food Systems Lecture Series (virtual). March 8, 2022.
- Lansing, S., 2022. Biogas and bioplastics: Valorizing food waste, algae, and manure. Institute of Marine and Environmental Technology (IMET) Seminar, University of Maryland Center for Environmental Science (virtual). February 2, 2022.
- Lansing, S., 2022. Returned Peace Corps Volunteer Experience. Discussion panel for students interested in Peace Corps. College Park, MD. February 1, 2022.
- Lansing, S., Hassanein, A., 2021. On-farm renewable energy through anaerobic digestion. Cecil County Land Trust Anaerobic Digestion Roundtable, with representatives from US Senate, MD legislators and MD Governor's office. Elkton, Maryland. October 28, 2021.
- Lansing, S., 2021. Bringing renewable energy access to rural communities: Challenges and opportunities (invited panelist). College of Agriculture and Natural Resources (virtual). October 15, 2021.

Presentations (without Proceedings)

- Amradi, N.K., Hassanein, A., Lansing, S., 2022 Volatile Fatty Acids and Bioplastic Production from Food Waste using Dark Fermentation. Northeast Agricultural and Biological Engineering Conference (NABEC), Edgewood, Maryland, July 31- August 3, 2022.

- Lansing, S., Hassanein, A., Mahoney, K., Amradi, N.K., Loraine, G., 2022. Biogas generation from food waste and black water using hydrodynamic cavitation, anaerobic digestion, microbial electrolysis, and electrocoagulation integration. Northeast Agricultural and Biological Engineering Conference (NABEC), Edgewood, Maryland, July 31- August 3, 2022.
- Lansing, S, 2022. Increasing the viability of our food systems and the value of our food waste. Northeast Agricultural and Biological Engineering Conference (NABEC), Edgewood, Maryland, July 31- August 3, 2022.
- Delp, D., Hassanein, A., May, P., Lansing, S., 2022. Fertilizing lettuce with algae, manure, and food waste co-digestion effluent. Northeast Agricultural and Biological Engineering Conference (NABEC), Edgewood, Maryland, July 31- August 3, 2022.
- Chatterjee, U., Felton, G., Hassanein, A., Lansing, S., 2022. Characterizing Poultry Litter Derived Biochar with Nitrogen Rich Digestate Effluent as Soil Amendment. Northeast Agricultural and Biological Engineering Conference (NABEC), Edgewood, Maryland, July 31- August 3, 2022.
- Na, S., Armadi, N.K., Hassanein, A., Lansing, S., 2022. Methane potential of fermented food waste. Summer Opportunities in Agricultural Research and the Environment (SOARE) Closing Presentation. College Park, MD. July 29, 2022.
- Lansing, S., Hassanein, A., Mahoney, K., Amradi, N.K., Loraine, G., 2022. Biogas generation from food waste and black water using hydrodynamic cavitation, anaerobic digestion, microbial electrolysis, and electrocoagulation integration. American Society for Agricultural and Biological Engineering (ASABE) Conference. Houston, TX. July 17-20, 2022.
- Delp, D., Hassanein, A., May, P., Lansing, S., 2022. Co-digestion of manure and food waste with algae harvested from an algal flow way (AFW). American Society for Agricultural and Biological Engineering (ASABE) Conference. Houston, TX. July 17-20, 2022.
- Poindexter, C., Lansing, S. Yarberry, A., Rice, C., Georgakakos, C., Gooch, C., 2022. A Mass Balance Approach to Antibiotic Resistance Partitioning in Dairy Manure Through A Continuous High Temperature Rotary Drum Composting Bedding Recovery Unit. American Society for Agricultural and Biological Engineering (ASABE) Conference. Houston, TX. July 17-20, 2022.
- Poindexter, C., Yarberry, A., Rice, C., Lansing, S. 2022. Correlation of Antibiotic Resistance and Temperature During Anaerobic Digestion of Dairy Manure. American Ecological Engineering Society (AEES) Conference, Baltimore, Maryland. June 20-23, 2022.
- Mahoney, K., Hassanein, A., Lansing, S., Kumar, N., Loraine, G., 2022. Energy Production and Waste Treatment from Food Waste and Blackwater through Integrating Anaerobic Digestion, Hydrodynamic Cavitation, Microbial Electrolysis Cells, and Electrocoagulation. American Ecological Engineering Society (AEES) Conference, Baltimore, Maryland. June 20-23, 2022.

- Amradi, N.K., Hassanein, A., Lansing, S., 2022. Dark Fermentation for Volatile Fatty Acids to Produce Bioplastics from Food Waste. American Ecological Engineering Society (AEES) Conference, Baltimore, Maryland. June 20-23, 2022.
- Delp, D., Hassanein, A., May, P., Lansing, S., 2022. Co-digestion of manure and food waste with algae harvested from an algal turf scrubber. American Ecological Engineering Society (AEES) Conference, Baltimore, Maryland. June 20-23, 2022.
- Chatterjee, U., Felton, G., Hassanein, A., Lansing, S., 2022. Utilizing Poultry Litter Derived Biochar as Soil Amendment. American Ecological Engineering Society (AEES) Conference, Baltimore, Maryland. June 20-23, 2022.
- Poindexter, C., Yarberry, A., Rice, C., Lansing, S. 2022. Comparative Analysis of Mesophilic and Thermophilic Anaerobic Digestion on the Reduction of Antibiotic Resistance within Dairy Manure. American Society of Microbiology. Washington D.C. June 9-13, 2022.
- Lansing, S., Amradi, N.K., Hassanein, A., 2022. Valorizing food waste through dark fermentation to bioplastics production. Society for Industrial Microbiology and Biotechnology (SIMB) Conference. New Orleans, LA. May 1-4, 2022.
- Chatterjee, U., Felton, G., Hassanein, A., Lansing, S. Utilizing Poultry Litter Derived Biochar as Soil Amendment in Ornamental Plants. National MANRRS conference, Division 1 Graduate Oral Competition in Biological, Physical, and Life Sciences, March 23-26, 2022, Jacksonville, Florida, 1st Place Winner Graduate Student Presentations.
- Schiavone, D. F. 2022. Solar Energy Education and Training. Association of Natural Resource Extension Professionals. Kalamazoo, MI. June 1-3, 2022.
- Schiavone, D. F. 2022. On-Farm Solar Energy Opportunities and Training. National Extension Energy Summit & National Sustainability Summit. State University, PA. May 15-18, 2022.

Posters (without Proceedings)

- Amradi, N.K., Hassanein, A., Lansing, S., 2022 Biological Conversion of Food Waste to Bioenergy and Bioplastics (poster). Postdoc Research Symposium, University of Maryland, September 23, 2022.
- Poindexter, C., Yarberry, A., Rice, C., Lansing, S. 2022. Two-step multi-residue antibiotic extraction method for comparison of antibiotics concentrations in manure as it moves through a manure treatment system (poster). American Society of Mass Spectrometry, Minneapolis, MN. June 6-9, 2022.
- Schiavone, D. F. 2022. Developing Energy Extension and Outreach Initiatives in Maryland. American Society of Agricultural and Biological Engineers. Extension Professionals. Houston, TX. July 17-20, 2022.
- Schiavone, D. F. 2022. On-Farm Solar Energy Opportunities and Training. Northeast Agricultural and Biological Engineering Conference. Edgewood, MD. August 1-3, 2022.

Reports

- Loraine, G., **Lansing, S**., Hassanein, A., 2021. Production of biogas for energy generation using hydrodynamic cavitation, anaerobic digestion, and microbial electrolysis cells. Final Report DOD: Army STTR Final Report. 51 pages.
- Maryland Food System Resiliency Council, 2021. Maryland Food System Resiliency Council Interim Report to the Maryland General Assembly. Available at: https://mdem.maryland.gov/Documents/MFSR_Council_Interim_Report_MGA_11012021.pdf. 86 pages.

Other Creative Works

- Anaerobic Digestion with Stephanie Lansing., 2022. Bioenergy Devco. Available at: https://www.youtube.com/watch?v=aRItrVLsI30.
- Tales of the Resistance, 2021 (podcast). Episode 4: Meet the Team – Stephanie Lansing. iAMR podcast series. Available at https://lpelc.org/episode-4-meet-the-team-stephanie-lansing/ Duration: 15 minutes.
- Accuweather Prime TV, 2021 (national TV show/video). Team of researchers studying how to turn trash into energy. Air date: November 21, 2021. Available at: https://www.accuweather.com/en/videos/team-of-researchers-studying-how-to-turn-trash-into-energy/39Gf58k0
- **Schiavone, D. F.** 2022. How to select and install a solar disconnect switch. *The University of Maryland Extension*, Educational Video. October 27, 2022; Duration: 12:01.
- **Schiavone, D. F.** 2022. How to size and select a solar inverter. *The University of Maryland Extension*, Educational Video. September 20, 2022; Duration: 15:50.
- **Schiavone, D. F.** 2022. How to wire a solar charge controller and battery bank. *The University of Maryland Extension*, Educational Video. August 15, 2022; Duration: 10:53.
- **Schiavone, D. F.** 2022. How to select and size a solar charge controller. *The University of Maryland Extension*, Educational Video. July 17, 2022; Duration: 14:12.
- **Schiavone, D. F.** 2022. How to design and size a solar battery system. *The University of Maryland Extension*, Educational Video. June 12, 2022; Duration: 15:42.
- **Schiavone, D. F.** 2022. How to wire different sizes of solar panels together. *The University of Maryland Extension*, Educational Video. May 4, 2022; Duration: 12:04.
- **Schiavone, D. F.** 2022. How and why to wire solar panel in parallel. *The University of Maryland Extension*, Educational Video. April 8, 2022; Duration: 13:17.
- **Schiavone, D. F.** 2022. How and why to wire solar panel in series. *The University of Maryland Extension*, Educational Video. March 7, 2022; Duration: 13:05.
- **Schiavone, D. F.** 2021. How to wire a solar combiner box or pass through box. *The University of Maryland Extension*, Educational Video. February 7, 2022; Duration: 13:56.
- **Schiavone, D. F.** 2021. How to wire a solar junction box and assemble PV cables. The University of Maryland Extension, Educational Video. January 6, 2022. Duration: 10:19.

- **Schiavone, D. F.** 2021. How to size wires and fuses for a solar electric system. The University of Maryland Extension, Educational Video. December 8, 2021; Duration: 10:46.
- **Schiavone, D. F.** 2021. How to estimate the size of your solar electric system. The University of Maryland Extension, Educational Video. November 1, 2021; Duration: 14:53.
- **Schiavone, D. F.** 2021. How to Perform a Site Assessment and Shading Analysis for Solar. The University of Maryland Extension, Educational Video. October 4, 2022; Duration: 14:16.

EXPERIMENT STATION: Virginia

Presentations

- Bovay, J., Ignosh, J., Berryhill, A., Daniels, W., Fike, J., & Meyers, R. (2022). Development of Large-Scale Solar Projects in Virginia. In Virginia Cooperative Extension 2022 Professional Development Conference. Virtual.
- Ignosh, J., & Ogejo, J. (2022). Abating Particulate Matter Emissions from On-Farm Poultry Litter-Fueled Energy Systems. Waste-to-Worth Conference. Oregon, OH. Retrieved from https://lpelc.org/
- Rogers, J. (NCSU)., Strong, R. (UMass-Amherst), Breger, D. (UMass-Amherst), Ignosh, J. (2022). "Dual Use Solar Project Experiences from North Carolina and Massachusetts".
- Ignosh, J. (2022). "Solar-Powered Water Pumping Systems - Options for Tenant Farmers".
- Ignosh, J. (2022). "Introduction to Micro-hydro Electric Systems".
- Friedel, J., & Ignosh, J. (2022). Solar Land Use Considerations. Webinar.
- Ignosh, J., Havranek, T. R., & Taylor, T. R. (2022). Webinar: "An Introduction to Multicriteria Decision Analysis".
- Friedel, J., & Ignosh, J. (2022). Solar Land Lease Considerations. Webinar.
- Ignosh, J., Havranek, T. R., & Taylor, T. R. (2022). Multicriteria Decision Analysis (MCDA) as a potential stakeholder-engaged methodology in evaluating design alternatives, including opportunities for co-benefits (e.g., agrivoltaics), with utility-scale solar projects. Blacksburg, VA.
- Ignosh, J. (2022). "Extension Programing and Farm Energy Issues", Romanian-American Foundation Visit. Weyers Cave, VA.

Other Creative Works

- Goerlich, D., Donovan, P., Herndon, B., & Ignosh, J. (2022). "Virginia Land and Energy Navigator “VaLEN” Initial Report on the Development of a Map for Prime Farmland HB894 Workgroup (Chapter 488, 2022)"
- Ignosh, J., & Booher, M. (2022). Solar Water Pumping for Livestock: Exploring Options for Tenant Farmers.
- Ignosh, J., Bovay, J., Daniels, W., Fike, J., Lane, R., Meyers, R., Munsell, J., Paulette, M., Pent, G., Prysby, M., Sample, D., Shortridge, J., Welbaum, G. (2022). "A Better Solar “Panel” from Virginia Tech", Poster Session. Poster session presented at the

meeting of Center for Advanced Innovation in Agriculture (CAIA) Big Event. Blacksburg, VA.